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PORTO RICO AGRICULTURAL EXPERIMENT STATION,
D. W. MAY, Special Agent in Charge.

ANNUAL REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION FOR 1911.

UNDER THE SUPERVISION OF
OFFICE OF EXPERIMENT STATIONS,
U. S. DEPARTMENT OF AGRICULTURE.

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PORTO RICO AGRICULTURAL EXPERIMENT STATION.

[Under the supervision of A. C. True, Director of the Office of Experiment Stations, United States Department of Agriculture.]

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LETTER OF TRANSMITTAL.

PORTO RICO AGRICULTURAL EXPERIMENT STATION,
Mayaguez, P. R., December 21, 1911.

SIR: I have the honor to transmit herewith and to recommend for publication the Annual Report of the Porto Rico Agricultural Experiment Station for the fiscal year ended June 30, 1911.

Respectfully,

D. W. MAY,
Special Agent in Charge.

Dr. A. C. TRUE,
Director, Office of Experiment Stations,
United States Department of Agriculture,
Washington, D. C.

Publication recommended.
A. C. TRUE, *Director.*

Publication authorized.
JAMES WILSON,
Secretary of Agriculture.

CONTENTS.

ILLUSTRATIONS.

ANNUAL REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION FOR 1911.

SUMMARY OF INVESTIGATIONS.

By D. W. May, *Special Agent in Charge.*

INTRODUCTION.

During the year great progress was made and a large increase shown in the production of the island. This amounted in value to over $10,000,000 above the figures for the previous year. The trade of Porto Rico has shown a steady increase since the American occupation, growing from $16,600,000 in 1900 to $78,700,000 in 1911. While the trade with foreign countries has grown, that with the United States has increased at a much greater rate. Porto Rico's purchases from the United States were exceeded by only 12 foreign countries, and were greater than those of Hawaii, Alaska, or the Philippines.

Of the $40,000,000 of exports, agricultural products, raw and manufactured, made up the entire sum. Sugar still leads the list, but there is a greater proportionate gain in some other products. Among the manufactured products tobacco stands first. Cigars in excess of $5,000,000 were exported. Other manufactured products were preserved fruits, straw hats, and distilled spirits.

The weather conditions of the year were good; in fact, crop failures in Porto Rico are unknown. It is true that on the south side of the island there is usually a shortage of rain for the best growth of the sugar cane, but with the development of irrigation systems a crop is assured even here at all times. The increase in the production of the island has been due to better cultivation and fertilization rather than to the extension of the area planted. The better cultivation has been brought about by a study of conditions and the extended use of machinery. Labor in general has been plentiful and is considered cheap. It is getting scarce in some industries and, moreover, it is not cheap as compared with efficient machine labor. The man with the hoe at 50 cents per day can not compete with the man with the plow at $3 per day. The real way to economize labor is by placing machinery in its hands.

Porto Rico purchased during the year over one million dollars' worth of fertilizers. That a return for this outlay was received there

is no doubt. It is very important, however, that individual planters make a more thorough study of the fertilizer needs of their soils, with the object of getting a greater profit on the outlay under this head. There is need in Porto Rico for an efficient fertilizer law as, judging from some analyses made by the station, there are fertilizers sold in the island which are below the claims made and not worth the price paid for them. In lieu of a good inspection law planters should combine, as some have done, in the purchase of fertilizer materials. They can thus buy in larger quantities and afford to have analyses made. In some cases they can profitably mix their own fertilizers and reduce the cost. This has an added advantage in the fact that it induces planters to make a closer study of their soils and secure a more economical improvement.

The trend of agriculture in the island is toward more intensive methods. The cultivation of tropical soils is expensive. This is due to their heavy nature, but more especially to the rank weeds and grasses with which the cultivator has to contend. In countries above the frost line a start is made each season with clean land. In the Tropics it is not so, for vegetation is always present, and to subdue the land requires greater effort. Steam plowing may cover the grass and weeds deep enough to cultivate and plant at once, but in plowing with animals it requires several breakings and cultivations to subdue the wild growth and put the ground in condition for planting.

Steam plowing is carried on to a great extent by the larger companies engaged in sugar planting. The cable plow is more in favor, as it operates to better advantage in cane fields, which are still crossed with many surface ditches for drainage. Perhaps lighter plows with gasoline power could be used in some areas. The drawback to the cable plow is the large original cost of the equipment. When tile drainage is more generally practiced in Porto Rico, as it should be, traveling power plows can doubtless be used to advantage.

The station lowlands have been drained with earthen tile made on the property. The tile have been in operation seven years and are a success. During the year a machine which makes cement drain tile at a greatly lessened cost was purchased. The making of cement tile can be carried on during rainy weather, and 2 men can operate the mill, while 10 men are required to make clay tile. Moreover, the burning of tile, where wood is scarce, as it is here, is expensive.

In the cultivation of Porto Rican soils, then, great improvement can be made along the following lines, namely: By better cultivation, with the substitution of machine for much of the hand labor; by better and more economical fertilization, to be brought about by individual study of each plantation; by tile drainage in wet lands and more irrigation in the dry sections.

SUGAR CANE.

Sugar cane, the principal crop of the island, showed some increase in production during the year, and the crop generally was good. There was some extension, mainly in the interior valleys, and several small mills were erected. Good profits in the sugar industry cause an extension to less profitable lands, sometimes without due consideration. The expansion of an industry usually follows a prosperous year. Investors do not always take account of unfavorable years. While profits in sugar since the American occupation have been large, yet sugar production is a precarious business, and without the sustaining tariff it would require greater skill and study than is now employed to keep the industry from lapsing into the condition prevailing during the Spanish régime. That the more progressive planters realize this is shown by the increased study of improved methods and the applications of science to their industry. This is best exemplified in the recent establishment for the study of problems of sugar production of the sugar planters' station, which is supported by a tonnage tax on the industry.

The breeding and the introduction into Porto Rico of new varieties of cane will undoubtedly greatly improve the yield of sugar. Permanent irrigation works on the south side of the island and tile drainage on the north will also mean much for sugar production in the island.

COFFEE.

The coffee crop during several years has varied with the character of the season. Comparatively little coffee has been planted, but there is better cultivation of the old plantings. There will continue to be an improvement in methods and in the quality of our coffee, but it is not likely that there will ever be any great extension of the industry in Porto Rico. It is true that the increased price of the last year has given some encouragement to coffee growing, but other economic factors are causing a gradual change in the agricultural production of the island that is every year more manifest. Coffee is a crop for outlying districts, for, being a compact, nonperishable product, it may be profitably transported long distances over bad roads and mountain trails. Porto Rico is coming every year closer to the door of New York, the best market in the world. With better steamer connections and the extension of macadam roads throughout the island, the lands become more available for diversified crops. With quick and frequent means of transportation perishable crops become more remunerative. This is having its effect on the coffee industry, and there are many evidences of a change of coffee plantations to fruit orchards. The areas planted to pineapples and citrus fruits, and even cane, are encroaching upon the coffee plantings. It is

contrary, too, to the best practices in agriculture to replant a waning crop on land that has produced it for many years. Moreover, coffee stands almost alone as the one crop lacking the stimulus of a customs tariff, while the sugar and fruits of Porto Rico are favorably treated in that respect.

TOBACCO.

Porto Rico exported tobacco during the year to the value of almost $7,000,000. By far the greater part of this was manufactured. Unmanufactured tobacco to the value of $1,500,000 was exported and $360,000 worth was imported.

The manufacture of tobacco has increased at a greater rate than its production. A larger number of persons are engaged in it than in any other manufacturing industry on the island. The people are singularly adept in the manufacture of cigars and cigarettes, and while the best tobacco lands are perhaps already closely planted, there will doubtless be a much greater increase in the manufacture of tobacco.

FRUITS.

The growth in the fruit industry in Porto Rico during a decade has been nothing short of marvelous. From nothing it has grown to a shipment during the year of over $1,800,000 in value. The planted groves are really only just beginning to bear. Fruit growing is destined to be one of the leading industries and in a few years it may surpass sugar in the value of the output.

The grapefruit of Porto Rico is meeting with great favor, and the quality of the oranges will become more evident as the trees grow older. Prices for citrus fruits as well as for pineapples have been satisfactory during the year. The prices for pineapples have been so favorable for the whole fruit that a smaller proportion than usual has gone to the canneries.

The problems facing the fruit grower appear less formidable than in the earlier years of the industry in Porto Rico. Many mistakes may now be avoided and groves brought into better bearing at a lower cost. The importance of protection from wind is now fully appreciated, and more careful packing is the constant study of the growers. The value of brands and trade-marks is receiving due attention from the best planters. The question of varieties and the study of local conditions have been much furthered.

Associations among the fruit growers have been of great advantage, the horticultural society studying production and the exchange concerned in the cooperative marketing of the fruit. Neighborhood associations, too, have helped in studying local questions and also in

some instances in the buying of fertilizers, in road building, and in improved shipping facilities.

Agricultural productions are increased with the areas under cultivation. Tree production, other things being equal, increases with the growth of the trees and the consequent extension of the bearing surface. Not only is the productive area enlarged by the extending branches, but the feeding surface of the roots is more extensive than with smaller crops. Porto Rico is destined to be an immense tropical garden—a greenhouse for the eastern seaboard cities of the United States.

INTENSIVE FARMING.

Agriculture in Porto Rico since the American occupation has been pioneering. This has been due to two causes: (1) The change from old to new and improved methods in agricultural practice, and (2) the change from two staple crops to a long list of diversified productions. The change has been retarded by local traditions and by soil depleted by continuous cropping under old wasteful methods.

There is a wide difference here between the production of the best and of the poorer lands. This is shown in values, which vary on a single farm from $20 to $200 per acre. The lowlands are the more valuable and, with the exception of the sandy strip bordering the seashore, are devoted to sugar cane. The mountain lands are devoted to coffee, while the intervening hills are the areas now being planted more to fruit.

It is the fruit grower who has the most difficult problem to face. The foothills have been cropped for many years and have finally been denuded of all forest growth and practically abandoned. As one proceeds toward the Equator it is found that land denuded of trees and cropped for a term of years becomes increasingly unproductive. Whether this is due to the influence of the sun rays, bacteria, or protozoa, it is more difficult to bring the land back to profitable production than in the North. In Porto Rico one of the most serious problems is to restore the deforested foothills to a condition of profitable production.

Fruit growers are doing more than any others to bring this about. They have made great progress, especially on the north side of the island, in improving worn-out land, and they have seen not only their own, but their neighbors', land greatly increased in value through their efforts. Two points are called to their attention: First, they are advised to diversify their efforts and especially to grow more products to improve their living conditions. Even on plantations of great value, if devoted to one main crop, the living conditions of the people dwelling thereon could be greatly improved and a higher standard of living brought about by growing minor crops and live

stock that are the accompaniment of even the most humble household in countries where the practice of agriculture has made the greatest advancement. In the second place, the waste places on the farm should be planted. There really need be no waste land in Porto Rico, but all of it may be profitably utilized. The lands are increasing in value at such a rate that their owners can not afford to allow them to remain idle. Many idle areas could be planted to leguminous trees to serve later as shade and windbreaks for fruit, cacao, or coffee.

EXPERIMENT STATION.

The work of the station during the year continued along the well-planned lines previously prescribed. Owing to the many problems and the few workers in the improvement of tropical agriculture, the funds of the station are wholly inadequate to its needs. Equipment needed for further study of fundamental conditions is very necessary for continuing the work. Funds are needed for improving the property of the station and for placing the work in such condition that employees can work to the best advantage for the acquirement of those results that will inure to the benefit of all the people.

REPORT OF THE CHEMIST.

By P. L. Gile.

INTRODUCTION.

The chemical work the past year, as in the previous three years, has been directed chiefly to soil and plant-nutrition investigations. Those investigations begun in the past have been continued, and one or two new problems have been taken up. The importance of restricting the chemical work to these two lines is becoming more evident with the development of more intensive agriculture on the island. It is becoming apparent to the planters that increased production in many cases can come only from an improvement in the methods of soil treatment. The increase in the number of soil samples sent to the station with request for advice as to the proper treatment indicates the extent to which this desire is growing. In many instances this advice can be readily given, in other cases the problems involve questions peculiar to the Tropics that have never been thoroughly investigated. As facilities permit, investigations of the more pressing problems are taken up, but as with most agricultural problems, the solution of soil difficulties is one requiring long-continued investigation. The only way that we may arrive at a more rapid solution of the problems is by increasing the means for experimentation and the number of individual tests.

During the past year progress has been made in this respect. By the cooperation of the planters it has been possible to greatly extend the number of field experiments conducted under the supervision of the station. Some planters are also trying various methods of soil treatment and reporting the results. It has thus been possible to increase the scope of the investigations already under way by increasing the field plats.

There are many soil problems, however, that can not be investigated by field experiments, but must be studied by means of pot experiments. It is important that facilities for pot experiments should be increased in order that this work may be carried on more effectively and conclusions arrived at more rapidly. The laboratory is now fairly well equipped to carry on the work under way and to take care of increased investigations. In the laboratory, however, only one side of the questions can be investigated. With increased equipment for conducting pot experiments the efficiency of the chemical work could be more than doubled and certain elementary

and important problems, such as the fertilizing value of our native bat guanos, could be solved in a much shorter period of time. The cost of the increased necessary equipment would be about $3,000. It is hoped that this may be secured as soon as possible.

SUMMARY OF THE WORK.

The analytical work of the past year has consisted in 60 analyses of miscellaneous materials, such as limestone, bones, yams, waters, sugar canes, fertilizers, and bat guanos, and about a hundred complete analyses of soils and plant ashes.

The investigations of previous years that are being continued are on soil disinfection; the availability of nitrogen and phosphoric acid in the native bat guanos; the effect of strongly calcareous soils on the growth and composition of various plants; the action of lime in inducing chlorosis; and the effects of various ratios of lime and magnesia on the growth of plants. Results secured on this latter problem are now being prepared for publication, and further experiments on the subject will be carried on this coming year.

Two new problems have been taken up the past year; one on the best treatment of the red clay soils, the other on the chlorosis of sugar cane. This latter problem is being investigated in cooperation with the Sugar Planters' Station.

THE AVAILABILITY OF THE NITROGEN AND PHOSPHORIC ACID IN BAT GUANOS.

Considerable progress has been made in this subject. In order, however, to bring it to a more rapid completion, the increased facilities for pot experimentation mentioned above are necessary. Samples of bat guanos secured from various caves on the island are subjected to a complete chemical analysis as rapidly as the work permits. Besides determining the amount of plant food in the guanos, the availability of the nitrogen and phosphoric acid are tested by chemical methods. The typical guanos are then tested in pot cultures to determine the immediate availability of these constituents to plants. To determine the more lasting cumulative effect of the bat guano on the fertility of the soil a series of 15 tenth-acre plats has been started at Anasco. A typical bat guano is being tested there in comparison with basic slag.

This work when completed will furnish specific knowledge of the chemical composition and agricultural value of a number of large bat-guano deposits and also such a knowledge of the various types of guanos that when samples are sent in for examination their value can be approximately determined by assigning them to one of the types that has already been thoroughly tested.

By testing the availability of the nitrogen and phosphoric acid as determined by vegetation experiments compared with that determined by chemical methods, a short method may be found for determining the approximate value of these deposits. In the report for 1908, analyses are given of various guanos. Since then samples have been analyzed from time to time for nitrogen and phosphoric acid, and because of the general interest in these deposits the data are here given:

Nitrogen and phosphoric acid in some bat guanos.

Sample No.	Location of deposit.	Nitrogen (N).	Phosphoric acid (P_2O_5).
		Per cent.	*Per cent.*
127	Bayamon		16.18
128	do		8.09
227	Boqueron	0.79	18.60
228	do	.40	24.06
247	Las Marias	3.09	9.44
248	do	3.01	5.31
249	do	.57	10.46
250	do	5.49	4.94
251	do	3.95	4.59

The following guanos have been subjected to a more complete analysis and are being used in pot experiments to determine their availability. The results are calculated on the basis of moisture-free material.

Analyses of bat guanos from various sources.

Composition.	Location of deposit.								
	Aguadilla.	Arecibo.	Las Marias.	Las Marias.	Cabo Rojo.	Cabo Rojo.	Cabo Rojo.	San German.	Vega Baja.
	Lab. No. 263.	Lab. No. 374.	Lab. No. 375.	Lab. No. 376.	Lab. No. 321.	Lab. No. 415	Lab. No. 460.	Lab. No. 458.	Lab. No. 447.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Total nitrogen (N)	0.40	0.52	0.66	3.23	1.63	0.65	0.97	1.32	1.06
Potash (K_2O)	.64	.96	.18	.25	.....	.24	.32	.77	.42
Total phosphoric acid (P_2O_5)	7.77	12.68	18.55	4.35	14.47	20.31	13.56	13.85	26.18
Water soluble (phosphoric acid)	.28	.82	1.10	.46	.53	.41	.....	.51	.33
Citrate soluble (phosphoric acid)	2.64	2.14	2.89	1.96	3.24	1.20	5.85	4.78	10.12
Lime (CaO)	30.49	22.45	13.72	1.74	5.82	14.53	19.86	5.24	32.13
Magnesia (MgO)	Trace.	.20	1.15	.27	.....	.17	.20	.05	.10
Iron oxid and alumina (Fe_2O_3 and Al_2O_3)	3.38	8.71	10.80	12.95	9.07	8.85	8.99	7.22	6.01
Water	2.85	13.82	6.97	13.11	7.20	5.17	21.46	17.01	10.36
Volatile matter	27.65	22.02	28.32	56.67	28.98	17.45	26.34	38.69	19.04
Nonvolatile ash	69.50	77.98	71.68	43.33	71.02	82.55	73.66	61.32	80.96
Carbon dioxid (CO_2)	.....	.57	.00	.00	.00	.....	.....	.....	.....

It is hoped that good progress will be made in the above work during the coming year, as the question is one of immediate and practical importance on the island. The guano deposits are very

numerous, and many are of considerable size. When it is known what quantity should be applied to replace the standard fertilizers and what the monetary value is, a considerable saving can be made in the purchase of commercial fertilizers by using these deposits. Many planters are now utilizing these deposits without knowing how much to apply to replace a given quantity of acid phosphate or sodium nitrate and without knowing whether it pays to use them. The results of the few trials of these materials that have been made by the planters in the past are not very enlightening, as they have used the guanos as complete fertilizers when it can be seen by the above analyses that most of them contain only phosphoric acid in appreciable quantities.

THE EFFECT OF VARIOUS RATIOS OF LIME AND MAGNESIA ON THE GROWTH OF PLANTS.

The results so far secured in the study of this subject are now being prepared for publication; they are, however, in the nature of a report of progress. The conclusions arrived at seem to show the problem to be more complicated than it is generally considered to be. The new phases of the subject that have appeared in the course of the work just completed are being investigated. In the work so far the effect of various ratios of lime and magnesia were tested by growing rice in nutrient solutions, employing the chlorids of calcium and magnesium. The effect of various ratios of lime to magnesia from 10:1 to 1:10 were tried. These ratios were also tried at different concentrations to see if the ratio of lime to magnesia would exert an effect in dilute as well as in concentrated solutions. The experimental results obtained were as follows: In the presence of a small amount of all the other nutrients equal percentage concentrations of calcium chlorid and magnesium chlorid appeared to be equal in their toxic action on rice. When compared on the basis of equivalent molecular quantities, calcium chlorid is more toxic for rice than magnesium chlorid.

In a concentrated solution of calcium chlorid containing a minor quantity of the other nutrients slight increases in the amount of magnesium chlorid greatly improved the growth of rice. A like improvement was produced in concentrated solutions of magnesium chlorid by small additions of calcium chlorid.

In solutions of 164 to 109 parts per 100,000 of the combined chlorids of calcium and magnesium, all the other nutrients being present in minor quantity, the growth of rice was distinctly better where lime and magnesia were present in the ratio 1:1 than in the ratios 10:1, 5:1, 1:5, or 1:10. The favorable action of ratio 1:1 compared with other ratios was more apparent the more concentrated the solutions.

In solutions of 62 to 23 parts per 100,000 of the combined chlorids, all the other nutrients being present, the growth of rice appeared to be unaffected by the ratio of lime to magnesia between ratios of 10:1 and 1:10.

The results of this work differ from similar studies by others on the lime and magnesia ratio in showing that, while the ratio appears to exert an action at comparatively high concentrations, it does not at low concentrations; at least not within the ratios tried. It is possible that at wider ratios than 10:1 and 1:10 an effect might have been observed even at low concentrations. The results show beyond doubt, however, that the effect of the ratio of lime to magnesia is much stronger at high concentrations of these salts than at low ones.

In considering this work together with recent work of other investigators on the toxicity of various salts and the antagonisms existing between them [1] it would appear that the question is not the simple one of a balancing of lime with magnesia, but a balancing of lime or magnesia with all the other nutrients. The facts seem to point to the conclusion that the toxicity of an excess of lime or magnesia is due not simply to an unfavorable ratio between these two salts, but to an unfavorable proportion between the salt that is in excess and all the other salts present.

In applying these results to soil conditions it must be taken into consideration that in ordinary soils the concentration of all the salts is exceedingly low, hence we should not expect the toxic action of any one salt to become apparent unless it were greatly in excess of all the others. In the soil we also have the physical effect of the soil particles diminishing the toxicity of any salt solutions.[2] It would seem, then, that the mere ratio of available lime and magnesia would be without much effect in ordinary soils. But in alkaline soils, where there is a concentrated salt solution, it appears that the ratio of lime to magnesia may be of the utmost importance in determining the growth of plants.

It is not intended to assert the above conclusions too positively, as this action of various salts and ratios of salt upon the growth of plants is a comparatively new object of investigation, and new facts and aspects of the subject are appearing rapidly. The above conclusions are based merely on the facts so far as now known.

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[1] Particularly the work of Loeb, Osterhout, True and Gies, and Lipman on balanced solutions.

[2] G. H. Jensen, Bot. Gaz., 43 (1907), p. 11.

THE EFFECT OF STRONGLY CALCAREOUS SOILS ON GROWTH AND COMPOSITION OF PLANTS.

The work on this subject has been in progress now for two years, and considerable data have been accumulated. It will take probably two years more to complete the work as originally outlined. The object of the investigation is to determine the adaptability of various plants to the limy soils.

This is thought to be one of the more important subjects under investigation. Excess of lime or lack of lime might be called the predominant chemical features of Porto Rican soils. Where there is a lack of lime, acid condition and its secondary effects are encountered; where there is a large amount of lime, many plants suffer from chlorosis. The strongly calcareous soils form a considerable portion of the arable land of the island. On the south and southwest sides of the island, between the mountains and the sea, nearly all the soils contain considerable carbonate of lime, often in an excessive amount, the percentages ranging from 2 per cent to 90 per cent. There are numerous outcroppings of calcareous soils on the north side, and much of the hill land also contains large amounts of lime.

It is well recognized in France and Germany that all crops are not suited to calcareous soils, but the effect of lime on most of the tropical crops is not known. In Porto Rico the limy soils bear a characteristic natural vegetation. It is important to know, however, how the growth of cultivated crops is promoted or depressed by various amounts of lime in the soil. In Bulletin No. 11 of this station it was shown that pineapples are sensitive to carbonate of lime in most soils, comparing with lupines in this respect. In the work carried on so far it appears that the growth of rice is also much depressed by carbonate of lime in the soil.[1] The depression appears to be so large that it probably would not pay to grow rice on most of our calcareous soils.

Some of the other plants tried appear to be unaffected by the carbonate of lime, while others make a better growth on the limy soils. As rapidly as the plants can be grown they are subjected to chemical analysis to determine what effect the lime in the soil has upon the ash content of the plant. It is hoped that this work may show why some plants are adapted to calcareous soils and why others are not.

THE CHLOROSIS OF SUGAR CANE.

This problem, which was taken up the past year, is being studied in conjunction with the pathologist of the Sugar Planters' Station. While this work has, of course, only been started, considerable prog-

[1] It was also noted in Hawaii that liming rice lands depressed the harvest (see Hawaii Sta. Rpt. 1907, p. 79).

ress has been made. Most of the bleached or chlorotic patches of cane have been visited and samples of the soil taken, together with samples of the adjacent soil where the cane is green. About 50 of these samples have been analyzed.

Cane seems to tolerate a considerable amount of calcium carbonate and to do best on soils containing a moderate amount. The best cane soils on the island contain sufficient lime to insure a neutral or slightly alkaline condition. Where the bleached cane has been observed thus far the soil is excessively calcareous.

So far as observed, the white or chlorotic cane seems to be confined to the southern and southwestern portions of the island. It occurs for the most part in patches varying from a tenth of an acre to several acres. In the neighborhood of Santa Ysabel, however, there are several hundred acres which are affected to a greater or less extent.

The soil survey of the chlorotic patches of cane is as yet incomplete, but from the results thus far it seems that the bleached cane is confined to patches of very calcareous soils. The typical chlorosis has not been observed on any soils but those very high in lime, no cases having occurred on the acid red clays. On the other hand, green cane has been observed on patches of soil containing as much carbonate of lime as the soils growing chlorotic cane.

From the similarity of the phenomena with that of the chlorosis of pineapples it was thought that treatment with ferrous sulphate might prove effective in restoring the green chlorophyll to the leaves. Accordingly, the leaves of a few high stools in the midst of a strongly affected patch of cane were brushed with a solution of the iron salt. The result was very striking, as a few days after the treatment the leaves became much greener. These leaves after brushing several times were killed by the solution, but perfectly normal green leaves started out from the top, which were in strong contrast to the white leaves of the surrounding cane. This, of course, was only a small test, but the result was so striking as to indicate that the need of the bleached cane was for iron.

An experiment is now being made in cooperation with the Guanica Central in spraying several good-sized patches of the chlorotic cane. An account will be kept of the cost of the treatment and of the frequency with which the iron solution has to be applied to maintain the normal green.

At Central Cortada a field experiment of some 15 tenth-acre plats is being laid out to find if there is not some way in which the sulphate of iron can be applied to the soil so that it may have a lasting effect. Spraying will also be tried in comparison to see which method of applying the iron is more effective.

THE ACTION OF LIME IN INDUCING CHLOROSIS.

This work is in some respects a continuation of the work published in Bulletin 11 of the station, where it was shown that the chlorosis or bleaching of the pineapples occurring on certain soils was induced by the calcium carbonate of the soil. It appeared in the course of this work that the chlorosis was due to a disturbance in the mineral nutrition of the plant, caused by the large amount of calcium carbonate in the soil. To make sure that this disturbance is the ultimate cause of the chlorosis, other plants that become chlorotic on limy soils are being studied. This work will be largely a correlation of the results secured from individual studies, such as that on pineapples, the one in progress on the chlorosis of sugar cane, and the study of the effect of calcareous soils on the growth and composition of various plants. While considerable progress has already been made on this subject there are many special phases to be investigated that present difficulties in laboratory methods and pot experiments.

ON THE TREATMENT OF THE RED CLAY SOILS.

It has been possible to commence work on this problem the past year through the cooperation of the Guanica Central. This company has kindly placed about 11 acres of land at the disposal of the station and is paying for the labor, fertilizers, and other materials used in the experiments. Thanks are due the company for thus making it possible to undertake this work.

Much of the red-clay soil that has been under continuous cultivation for many years is in what the physiologist terms a "sick" condition, the yield of cane being only 20 to 40 per cent of what should be expected. Applications of various fertilizers that have been made in the past seem to be ineffective in increasing the yield. To just what this nonproductivity is due is as yet uncertain. The investigations of the physiologists seem to point to the cause lying in the bacterial condition of the soil. Some of the red clay soil, however, is still in good condition, responding to fertilizers and yielding good crops of cane.

On account of the two different conditions obtaining on this type of soil the investigation has been divided into two parts. One part of the experiment consists in the investigation of the lime and fertilizer requirements of the soil which is in a productive condition. The experimental field for this purpose is located at Anasco. The other part of the investigation is devoted to the study of what has been termed "sick" soil. The experimental field for this purpose is located at Hormigueros.

For the fertilizer experiments at Anasco 45 tenth-acre plats have been laid out. The effects of the various fertilizing elements are being

tested singly and in combination. As this type of soil is almost uniformly acid, improvement is also to be expected from liming. Lime at the rate of 1,500, 2,000, and 4,000 pounds per acre has been applied to some plats, both with and without a complete fertilizer. All the plats are planted to sugar cane.

At Hormigueros, where the soil is out of condition, 42 tenth-acre plats have been laid out. A series of 8 plats which was started in 1909 shows that no improvement is to be hoped for on the land by the application of fertilizer alone. Accordingly, treatments are being tried for bringing the soil into a condition to respond to fertilizers and also to throw light, if possible, on what is the real cause of the low productivity. The following treatments are being tried:

(1) Aeration of the soil by plowing at intervals of a few weeks.
(2) Liming at rates of 2 and 4 tons per acre.
(3) Heavy liming with a subsequent application of barnyard manure.
(4) The plowing under of cowpeas previous to planting the cane.
(5) Disinfection with heavy doses of carbon bisulphid.

The latter treatment is being tried, not as a practical method of treating this soil, but to determine whether or not it is benefited by disinfection. The result of this treatment ought to throw some light on the cause of the trouble. Should the treatment prove beneficial the next problem would be to find a cheap germicide. There are various check plats in the experiment to determine the effect of barnyard manure and complete fertilizer alone as compared with no treatment. It is believed that this problem represents one of the fundamental soil problems in Porto Rico, and it is hoped that the experiments may throw some light on its solution.

REPORT OF THE HORTICULTURIST.

By C. F. Kinman.

CITRUS FRUITS.

The cooperative fertilizer experiments, the study of stocks, bud variation in navel oranges, cover-crop experiments, and variety testing are being continued. Numerous trips have been made to the groves where cooperative experiments are under way for the purpose of applying fertilizers, studying the progress of the plats, and harvesting the crops. A complete record was made of the number of fruits and the weight of the crop from each plat, which shows that the complete fertilizer has given the most profitable return this year. It is hoped that the results of these experiments, which have been conducted since 1906, may be published after this year's crop has been harvested.

In the variety orchard, located on high land, there has been great variation in the growth of the different varieties, but few of them proving to be at all satisfactory. Among the oranges the variety Hart Late has been the most promising. These trees withstand both the long winter drought and summer rainy season and are very prolific and regular in bearing. The fruit ripens in the last part of February or in March, and the crop remains on the trees without deteriorating until late in May. Under local conditions the skins are smooth, thin, and tough, the flesh, while somewhat fibrous, is very juicy, and the flavor very rich. If the fruit is left on the tree too long a greenish color will return.

Among the navel oranges cultivated on the island there is great variation in regard to the quality of the fruit, some trees bearing excellent juicy oranges, while the quality of others is quite the opposite. Evidence has been found to indicate that this difference is in some cases due to bud variation, and that the undesirable trees were propagated from trees with similar faulty characteristics. Material has been collected from different orchards on the island, and experiments to determine the cause of the variation in the quality of the fruit are under way.

PINEAPPLES.

An experiment to determine the practical effect of fumigating pineapple plants before setting to rid them of insects was begun in May, 1909, by the former horticulturist, Dr. M. J. Iorns. Both fumigated and check plats of 17 different varieties of pineapples were set in the

FIG. 1.—THE SWORD BEAN AS A COVER CROP.

FIG. 2.—THE POTATO YAM.

FIG. 1.—COWPEAS AS A COVER CROP FOR COCONUTS.

FIG. 2.—VELVET BEANS AS AN ORCHARD COVER CROP.

Fig. 1.—Inarching Mangoes—Seedlings Grown in Bamboo Pots.

Fig. 2.—Mulgoa Mango in Bloom. Tree 3 Years Old.

FIG. 1.—SHORTHORN NATIVE HEIFERS.

FIG. 2.—GUINEA GRASS GROWN FOR FORAGE.

experiment, and with most varieties large, medium, and small sized plants were used. Owing to the unfavorable weather conditions, the long winter drought, and excessive summer rains these plants have developed slowly, though each variety has produced fruit this year. From time to time during their growth the plants were examined, but no effect on the vigor of the plants resulting from the fumigation was observed, and within a few months after setting insects were found on the fumigated and check plants alike. The mealy bugs are quite active, and they soon went from the check to the fumigated plats and reinfested them.

Young pineapple plants taken from old fields are often badly infested with mealy bugs, and as fumigation strong enough to destroy the insects is not injurious to the plants, it could in many cases be used to advantage. However, as mealy bugs are so well distributed, the fumigation can not be expected to more than assure clean plants for setting, and the customary practices will have to be employed for keeping the plants free from insects after they have been set in the field.

During the latter part of the year plantings have been made to test the effect of leguminous cover crops and tree shade on a number of varieties of pineapples. The varieties Red Spanish and Cabezona were set in cover-crop experiments, and these varieties with a number of others were planted in the shading test. The cover crops planted were the sword bean (*Canavalia ensiformis*) (Pl. I, fig. 1) and pigeon pea (*Cajanus cajan*), or gandules, as they are commonly called here. Pithecolobium trees 7 years old are also being used for shade.

In the variety test field notes on the thriftiness of the plants and quality and quantity of the fruit of the 27 named varieties and of the number of seedlings grown at the station have been taken, and new plantings of each variety have been made for further comparison.

COVER CROPS.

Work with cover crops in citrus orchards reported on last year is still under way and has been taken up in coconut and pineapple plantations. Cowpeas, velvet beans, Canavalia or sword bean, and pigeon peas have given good results (Pl. II, figs. 1 and 2). The cowpea is not so desirable for summer planting on heavy soils as the other crops, as they mature early and often at a time when the soil is too wet for replanting or caring for a new crop properly. The other crops mentioned continue their growth throughout the season of heavy rains and make a dense cover that keeps down all the grass and weeds, and is also excellent for preventing soil washing. The cowpeas have produced good crops of seed when planted in the spring, while the winter-grown crops of the Canavalia and velvet bean are more prolific, as the

long winter drought checks the heavy vine growth and stimulates seed production. Also, as the summer rains cause the pods to decay the drier winter months are much more desirable for seed production. The Canavalia and velvet beans planted on low, heavy land April 10 have made an exceedingly good growth, the green weight of the vines 94 days from planting being 12½ tons per acre for the Canavalia and over 9 tons for the velvet bean.

VEGETABLES.

The study of the degenerating influence of Porto Rican conditions on a number of imported vegetable varieties, which was started two years ago, is being continued. Okra, beans, tomatoes, peppers, and lettuce have been grown through a number of generations, and interesting data have been taken. The indications are that at least the okra and beans have degenerated both in vigor of plants and productiveness. This work will be carried on through the fall and winter, and it is hoped that after that time conclusions worthy of publication will be reached.

ROOT CROPS.

Cultural, fertilizer, and variety tests with yautias, dasheens, and yams are still under way and have given good results. Of the 15 varieties of yams the varieties Potato (Pl. I, fig. 2) and Guinea seem the most promising for growing here. These varieties are well adapted to our soil and climatic conditions, producing heavy crops, and the tubers are the most desirable varieties for food that we have tested. Analysis made by the chemical department here shows that the percentage of starch in raw samples of the Potato variety was 23.55 per cent and of the Guinea 24.09 per cent. These varieties are 6 or 7 per cent higher in starch than are other varieties. The variety Potato has been distributed to planters in various parts of the island, while the Guinea has for some time been grown as a favorite variety among the gardeners.

Twenty varieties of sweet potatoes have been imported this year and tested. The summer crop was planted in heavy soil, and the varieties are showing wide differences in growth.

MISCELLANEOUS CROPS.

Strawberries.—The nine varieties of strawberries imported from the United States in November, 1910, bore fruit soon after setting and continued to bear sparingly until the summer rains began. The fruit was of good quality and size, but the crop too small to be profitable. The plants appear to be poorly adapted to the conditions here, as

their growth is very slow, and they continue to lose vigor. The varieties Klondike and Aroma seem to be the most hardy.

Eucalyptus.—The difference in vigor in our dozen and a half varieties that are growing in low, heavy land, which during the summer is very wet, continues to increase as the trees grow older. A disease apparently similar to crown-gall has killed a few small trees of different varieties, but the loss has not been sufficient to be considered serious. *E. robusta*, *E. piperita*, and *E. tereticornis* have grown well and are the only varieties that have made satisfactory growth under the field conditions mentioned above. Seedlings of the same varieties as the older plantings are being grown and will be set on high land for comparison with the low-land plantings. The study of soils for seed beds and methods of planting and caring for the seedlings are being carried on, and a large number of seedlings are being grown and distributed to planters over the island.

Bananas.—From the large number of banana varieties that were formerly grown at the station, 25 of the most promising were removed from the high land, where they had been growing, to a lower, more open soil. Each variety has shown a great improvement under the new conditions, though but few of them promise profitable production. Three varieties, which fruited first and which have so far been the most prolific, are the Gigante, Enano, and Manzano. A study of the varieties indicates that there are many duplicates in the station plantings, which would be expected, as the original collections were obtained from many countries and the common names used in the countries from which they were sent were given them here. The variety known in Porto Rico as Gigante appears to be identical with Gigante Guarán and Nada Fahonson imported from other countries, and the Porto Rican variety Enano the same as the imported kinds known elsewhere as Manzano, Cinea India, Apple, and Brazilian.

Mangoes.—The work of extending the planting and distribution of varieties, importing new varieties, studies in propagation, etc., is being continued. (Pl. III.)

The East Indian varieties fruited very poorly this year, the yield amounting to but a small percentage of last year's crop. The varieties Cambodiana, Mulgoba, and Sandershah were not productive this year. The fruit of the variety Cambodiana has in previous years been badly attacked by fruit flies at the time of ripening, but this year the injuries have been successfully prevented by bagging the fruits before they reached full size.

REPORT OF THE ASSISTANT HORTICULTURIST.

By T. B. McClelland.

COFFEE.

The various cultural methods formerly mentioned as being tried on coffee are being continued, and data as to height, number of producing trees, amount of coffee produced, etc., are being collected.

In addition to the old plantings of Porto Rican coffee there are a number of introduced coffees. Of the latter there are something more than 2,500 trees. Among species of coffee other than *Coffea arabica*, in its different varieties, are found *C. liberica*, *C. laurentii*, *C. excelsa*, *C. macrocarpa*, *C. stenophylla*, *C. canephora*, *C. zanguebariæ*, *C. dewevrei*, *C. liberica* × *C. arabica* hybrid, *C. mauritiana* × *C. laurina* hybrid, and several coffees of undetermined species.

Among coffees now bearing may be mentioned: Ceylon hybrid; Mocha hybrid; Blue Mountain, of Jamaica; Padang, of Sumatra; Preanger, Pantgoer, Erecta, and Columnaris, of Java; Guadeloupe; Maragogype; Surinam; and Mocha. A number of others should bear their first crop next season.

The coffee trees in the transplanting experiment begun in August, 1909, are now showing some interesting differences. The plants used were seedlings from the 1908 crop. When quite small they were taken from seed boxes and set in the nursery bed.

In transplanting young coffee trees from the nursery bed with only five to six pairs of leaves, careful setting with the root system bare gave as good results as with the root system encased in the surrounding clod. The tendency toward an earlier production was aided either by making the permanent planting when the trees were quite small, that is, less than a year old from seed, or by transplanting with the root system encased in the surrounding clod if the plants were allowed to remain in the nursery bed for a year longer. A more even stand is likely to be secured by allowing plants to remain in the nursery bed a year longer than by transplanting when plants have only five to six pairs of leaves. The cutting back and planting out as stumps of coffee trees less than 2 years old was very unsatisfactory where conditions were not very favorable for coffee culture.

Knowing that coffee seed does not long keep its viability, an experiment was made to see if it might be longer preserved by excluding the moist air of the Tropics. In the autumn of 1909 a number of well-matured coffee cherries were carefully picked, washed, and shade

dried for a week, after which they were divided into two portions, of which one was put in a cotton sack allowing free passage of air, the other in tightly closed jars containing under the coffee calcium chlorid as a drier. Every two weeks 100 seeds were planted from each lot. Of those planted up to 10 weeks from time seeds were picked from 94 to 100 per cent germinated. However, after 12 weeks the germination of seeds from the drier was only 27 per cent against a germination of 95 per cent of seed in open air. The last seeds from the drier which germinated, giving 5 per cent germination against 97 per cent for seeds in open air, had been kept 18 weeks. The seed exposed to air fell to 84 per cent germination at 20 weeks, keeping steady until 24 weeks, falling to 48 per cent at 26 weeks, and giving the final germination of 6 per cent at 32 weeks.

In December, 1910, some coffee seed from coffee prepared for distribution was thoroughly mixed and divided into six lots, being treated as follows:

No. 1. Seed in cotton sack in open air.
No. 2. Seed in close jar over water with evaporating surface of cotton cloth.
No. 3. Seed in oven-dried powdered charcoal.
No. 4. Seed in frequently remoistened charcoal.
No. 5. Seed in closed jar over calcium chlorid as drier.
No. 6. Seed in closed jar over concentrated sulphuric acid as drier.

For each test 100 seeds were planted, and two months were allowed for completion of test. A check lot of seeds planted on December 26 gave 92 per cent germination. The results of germination tests as influenced by treatment of the coffee seed are given below.

Germination of coffee treated in different ways.

Seed planted.	Germination.					
	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
1910.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Jan. 26	92	87	94	97	0	97
Feb. 25	80	57	78	86	0	78
Mar. 27	74	39	37	31	0	[1] 45
Apr. 26	49	16	36	([2])	0	0
May 26	21	19	29	.....	0	0
June 26	0	20	1	.....	.....	.....
July 26	0	11	0	.....	.....	.....
Aug. 28	0	[3] 24	0	.....	.....	.....

[1] On Mar. 27 the contents of a small bottle of sulphuric acid were poured into the bottom of jar containing coffee, giving a larger surface for evaporation of the liquid.
[2] No more planted, as seed were germinating in charcoal.
[3] This is not the ultimate germination from Lot No. 2.

In all these tests the seeds which were very severely dried for any considerable length of time had their viability destroyed, while the checks exposed to the open air and containing more or less moisture still continued to germinate. That the drying must be somewhat severe is shown by the following test made shortly after the comple-

tion of the ordinary preparation of coffee for market. One hundred seeds from a pile fermented over night gave a 92 per cent germination. From a lot which had been fermented and the sun drying completed the germination was 71 per cent.

The conclusions from these experiments are that the viability of coffee seed is destroyed by very severe drying and that a certain amount of moisture, as yet undetermined, is necessary for its prolongation.

On the college farm an experiment has been undertaken to find a means of ridding the coffee of the destructive ant, *Myrmelachista ambigua* subsp. *ramulorum*, which infests the guamá (*Inga laurina*). In one section both shade and coffee have been felled, in two others the coffee has been left standing, the shade being felled in one and girdled in the other. Throughout the whole, new shade trees, *Inga vera*, have been planted, and as temporary shade bananas, *Agati grandiflora*, and pigeon peas are being tried. In less than three months after the work was begun, in the section where both coffee and shade were felled, no ants whatever of this species could be seen except on the extreme edges of the plat. From the old coffee stumps strong renewal shoots are being sent up.

On a piece of nearly level land on the station grounds a planting of coffee has been made to test the effects of different fertilizers. It consists of 33 plats of 18 trees each. This will allow one or more duplicates for each test.

VANILLA, RUBBER, AND CACAO.

The vanillas received from the subtropical laboratory at Miami, Fla., in December, 1909, have made a very luxuriant growth. Of these, three Panama vanillas, a *Vanilla eggersii* from southern Florida, and a *Vanilla* sp., "Pompon," from Vera Cruz, blossomed in the spring and summer of the present year. As vanilla is found growing in various parts of the island, it is strange that more attention has not been given it as a commercial proposition. As soon as sufficient cuttings are available more extensive plantings of the commercial varieties will be made to demonstrate the possibilities of vanilla culture under Porto Rican conditions.

A tapping of 15 of the 8 to 9 year old Castilla trees has been made, and the average yield of rubber per tree is but very slightly greater than that of the year preceding.

In 1903 a small wind-protected ravine with sides rather steeply inclined and bottom well watered was set with cacao, most of the plants being from seed brought from Trinidad in March; a few were from seed from trees on the island. The following year a few cacaos were added from the United States Department of Agriculture.

From 272 trees still alive in 1910 the yield for the year ending December, 1910, averaged only about ¼ pound of dry cacao per tree. The conditions under which the trees are growing are at least up to the average for the island. The trees are planted at the rate of about 300 per acre. Cacao sells here at from 9 to 12 cents per pound. This means a gross return of from $6.75 to $9, making no allowance for the eating of ripe pods by rodents, the loss in this way being often very great.

REPORT OF THE ENTOMOLOGIST.

By W. V. Tower.

The fiscal year of 1911 was taken up in studying the white grub in the cane and a coffee ant which infests coffee and practically all its shade trees. Much time was devoted to the station apiary and to giving instruction in apiculture. Studies have been begun on the life histories of the insects affecting the guava, and some important facts have been learned. The station insect collection was greatly increased. Glass-covered mounts were made of many of the injurious insects; also different forms of the various insects were brought together. These were used for the exhibit and also for demonstrating at the insular fair. During March the station was asked by the mayor of San Juan to make a mosquito survey of that city. The writer was detailed by the director to take up this work. It was found that the mosquitoes of San Juan proper were breeding mostly in barrels, cisterns, tin cans, and in standing water. The mangroves around the bay were not breeding mosquitoes, as was supposed. A circular on the survey is now ready for the press. The yellow-fever mosquito was found breeding practically everywhere, as were various forms of Culex.

BEES.

The bee industry in Porto Rico continues to increase. During the past year demonstration classes have been held three times a week and these have been well attended. Most of those who have attended these classes have purchased bees from the station and have started small apiaries. Many of those who studied at the station during 1910 have established commercial apiaries and are now producing honey.

Since taking up this work the writer has studied the flora in practically all districts of the island. Porto Rico is well supplied with honey plants, and it is doubted if there are any localities in which bees would not pay. There are certain districts on the island which are considered especially fine pasturage; they are the foothills in the range of the coffee districts. In Mayaguez, for example, the coffee plantations come down to within about a mile of the sea. Thus, an apiary located near the outer edge of the coffee belt would have two different floras to work upon, i. e., the flowers of the pastures, such as small trees, shrubs, and ground flowers, and the coffee and its shade.

Coffee shade trees produce more honey than the coffee itself. A great number of shade trees are used in coffee plantations which produce nectar. In the lowlands guamá (*Inga laurina*) is used almost entirely, while in the interior the principal shade tree is guava (*Inga vera*). The guamá is by far the best honey plant on the island. This tree blooms from two to five times a year, and the bloom lasts from 10 to 15 days. It is not uncommon for a good, strong hive of bees to gather from 5 to 11 pounds a day. The honey is very light in color and resembles the clover honey of the North. It runs about 12 pounds to the gallon and wholesales in New York at about 85 to 90 cents a gallon.

Bees would probably be beneficial in the orange groves, especially during such seasons as the past, when there was a scarcity of orange bloom. If the planters had had plenty of bees they would undoubtedly have fertilized all the available blossoms, and a far greater crop of fruit would have set. Bees are very fond of the flowers. They gather both honey and pollen, collecting the pollen in large pellets to be used in the hive as food for the young brood. During a heavy flow of orange honey the odor of the plant may be recognized around the hives. Districts in which the cultivated orange is raised would probably not afford as good pastures as the coffee, but bees would be able to store sufficient honey so that they would not have to be fed. If feeding was necessary, the small amount of honey used by them would be repaid to the grower by the increase of his crop.

No bee disease has been observed, nor has any been reported to the station during the past year. A circular on beekeeping was published in English and Spanish.[1] This circular discusses the various appliances used in beekeeping, methods for manipulating bees, and a list of the more important honey plants on the island. The circular also takes up the question of the possibility of introducing bee diseases into the island. All beekeepers should realize the importance of keeping out bee diseases. In countries where foul brood has become established, it causes great losses every year. This disease is especially destructive in tropical countries, and it should be the aim of every beekeeper on the island to investigate the origin of all importations of bees, reporting the same to the experiment station at Mayaguez, or to the board of commissioners of agriculture at San Juan. The law prohibits the importation of bees in hives or nuclei, but it provides for the introduction of queens in mailing cages. Although the law is somewhat strict, it seems best to have it so, considering the importance of keeping out this dreaded disease—foul brood.

The station has had a great many inquiries as to how much honey a good colony would produce in a year. As no figures were available, two colonies were placed on a pair of scales and their weights taken

[1] Porto Rico Sta. Circ. 13.

morning and evening. Although the number of colonies was limited to two, some very valuable data were obtained. The readings showed at what seasons the bees were most active; also what flowers produced the greatest quantity of honey. During a period of nine months from one of the colonies there were extracted 470 pounds of honey, while the other produced 337 pounds. The only period when both colonies were not gathering was during September, and during this month the small colony gathered sufficient honey so that it did not have to use any of its surplus. Beginning the latter part of February and through March, April, and May, the bees worked on the general bloom, and it was not uncommon for them to gather from 1 to 2 pounds of honey per day. July and August were good honey months; during these two months one of the hives gathered 203 pounds of honey.

CITRUS-FRUIT PESTS.

The citrus fruit for 1911 was much freer from scale, russets, and scars than formerly, as the windbreaks are developing and giving the trees more protection. The beneficial fungi are holding the various scale insects in check, and in some groves the planters have not had to spray for scale for the past two crops. Scarred fruit is not as prevalent because the windbreaks keep out the wind and there is not so much rubbing, which eventually produces a scar. Many of the growers are using sulphur sprays for the rust mite, and there is a marked falling off of the percentage of rusty fruit. Bamboo continues to be the favorite windbreak; it is quick growing and gives protection in two years. The mango is also being planted, but it is much slower in developing. The one objection to both of these is that they are gross feeders. A ditch should be cut alongside of the plants to prevent their roots from extending out into the groves.

MANGO INSECTS.

The mango is one of the most productive fruits of the Tropics. It has many enemies, but, as practically no mangoes have been raised on the island for shipment, the planters have not become interested in their injurious insects. During the past few years, the experiment station at Mayaguez has imported choice varieties from India, the East Indies, and from the other West Indies. Some of these have borne fruit, and it was found that some of them were infested with fruit flies. Upon this discovery a preliminary study was made of the insects affecting the mature mango. The native mangoes, with one exception, are comparatively free from insects. The worst pest is a fruit fly (*Anastrepha acidusa*)[1]. It does not attack all varieties of mangoes, but is very partial to the Cambodiana, and

[1] Determined by W. R. Walton, Bureau of Entomology, U. S. Department of Agriculture.

it practically ruins this variety. It is almost impossible to find a ripe fruit which does not contain at least from two to five maggots. From some fruits from 20 to 25 flies have been raised. The adult fly is very similar to the fruit fly of the guava, and it may be the same species. The life history of this insect has not been completely worked out. The adult female lays her eggs in the green fruit. All sizes of fruit are infested, from those the size of large walnuts to those as large as hen eggs. The larva is a soft-headed worm, and it feeds on the fleshy part of the fruit. Some mangoes have been found containing larvæ in such numbers that the whole inside of the fruit was eaten, leaving only the skin, a mass of fibers, and the seed. Young mangoes badly infested drop to the ground long before they become full grown.

The mature larvæ bore through the skin and pass into the ground to a depth of about 1 to 1½ inches; there they pupate in about 24 hours. The immature larvæ are flesh colored, while the mature larvæ are yellowish. The newly formed pupa is yellow, but gradually turns to a deep reddish brown. The pupal period lasts from 13 to 16 days. The adult fly is about the same size as the common house fly. They are beautifully marked, the predominating color being yellow. The wings are transparent and marked with black.

No experiments on the control of this insect on the mango have been undertaken by the station, but in other countries considerable work has been done on other species of fruit flies. Poisoned sprays and baits are being used; also some beneficial parasites have been found.

A number of scale insects are found on the mango. A small white scale ("Indica") is found on the trunks and large branches. This scale is a pest in India, but in Porto Rico it does not seem to spread rapidly. On some of the trees at Mayaguez this scale has been found parasitized by two species of beneficial fungi; one, the common black species, occurring on the white scale of the orange, and a brown fungus, which is found on the purple scale in the mountains. These two fungi, it is hoped, will exterminate or hold this scale in check. It is believed that these fungi will not be effective in checking the scale on mango trees that are isolated from other trees, any more than do beneficial fungi check the various scales in orange groves where the trees are not protected from the wind. Windbreaks will be beneficial in controlling the soft lecanium, wax, orange, red, and small star scales. All these scales are found on the mango, but are held in check by parasitic fungi only when favorable conditions exist, such as protection from the wind and an excess of moisture. All the mango scale insects are found on the trunks, branches, and leaves, and not on the fruit.

Sooty mold is a fungus which obtains its nourishment from honeydew secreted by the lecanium scale, giving the trees an appearance of being covered with charcoal dust. Thrips are rather plentiful on some varieties of mangoes, especially those that are infested with the fruit fly. These insects are very small, almost microscopic. They obtain their nourishment from the leaves and unripe fruits through a minute proboscis. This insect passes its pupal stage in the ground, and in California it has been found that clean culture and frequent cultivation under infested trees during the pupal period is beneficial. Emulsions of kerosene and whale-oil soap are also successfully used as sprays in killing this insect.

REPORT OF THE PATHOLOGIST.

By G. L. Fawcett.

PLANT DISEASES.

Coffee.—More time has been given to coffee diseases than to other subjects. In the work with the root diseases several new methods for preventing the trouble were tried, but it is yet too early to get definite results from these experiments. The diseases of the fruit, which make the preparation of the grain more difficult by causing the flesh to adhere, and which, by spotting the grain, lower the quality of the product, have been studied and found to be due in part to improper shading and soil conditions. As the leaf rot spreads most rapidly at the time of the heavier rains, and its rapidly growing mycelium is especially sensitive at this time, it is important that sprays applied during this season should adhere well. For this purpose various adhesives were added to the Bordeaux mixture, among others the borax-starch mixture, which has been strongly recommended for use in cacao plantations in regions of heavy rainfall. Ordinary Bordeaux mixture made up with but half the usual amount of water without the addition of adhesives was found to adhere better than Bordeaux of the usual dilution mixed with any of those adhesives tried. It was necessary to discontinue the work with the West Indian coffee diseases until a more suitable place can be secured.

Coconuts.—A "bud rot" of the coconut has been found at various points along the western coast, as mentioned in previous reports, and probably it occurs in other parts of the island. It destroys some trees each year in many of the plantations, but the number of trees so lost seems to be comparatively small. There can be no doubt that some of the trees apparently suffering from this bud rot have been really injured by lightning. In every case studied bacteria have been isolated from the innermost diseased tissue, but uniformity in the results of such studies has not been obtained. In connection with this work other interesting though minor diseases of this plant were noticed.

SOIL BIOLOGY.

Some work with the bacteriology of "sick" soils was done on lines suggested by Dr. Oscar Loew. The only result of interest from this work was in finding in two of the worst soils a complete absence of

protozoa. The soils were taken from near the roots of a coffee tree which had recently died from the effects of unfavorable soil conditions and from one of the worst parts of a field of diseased cane in the San German Valley. A small area of each soil was disinfected by a heavy application of carbon bisulphid and samples taken from soil so treated and from the surrounding undisinfected soil. The samples of disinfected soil were taken about 6 inches below the surface and at a distance of 18 inches from the point where the application of the disinfectant had been made seven days previously. None of the cultures from these soils, either disinfected or nondisinfected, gave any growth of protozoa, although kept several weeks. Bacteria were abundant in the cultures of both soils. It is at least clear that any good results to be derived from the disinfection of these soils can not be due to the destruction of the protozoa, yet canes planted in boxes of the disinfected soil gave a much more vigorous growth than those planted in soil not disinfected.

A STUDY OF ROYAL-PALM ROOT NODULES.

It is well known that several nonleguminous plants harbor in their roots fungi which are probably beneficial in some way, such as rendering it possible for the plants to secure a larger supply of nitrogenous food. Of these plants *Podocarpus chinensis*, which bears fungus-inhabited nodules, has been grown for several years with no other source of nitrogen than that to be derived from the air.[1] Almost equally good evidence of ability to draw on the air as a source of nitrogen has been found for others of these plants, such evidence being based on ability to grow in nitrogen-free solutions or the proof of the presence of proteolytic enzyms in the nodules and the partially digested appearance of the contents of nodules when examined with the microscope.

In the root nodules of the royal palm of Porto Rico is found a fungus which resembles in some respects that described from the nodules of Podocarpus. This suggests that this palm also might be able to secure part of its nitrogen from the air. To test this point palms are being grown in clean sand and watered with a nitrogen-free solution and others with a complete nutritive solution.

Plants grown from disinfected seed in sterilized soil developed nodules which contained no fungus. On the roots of plants growing wild very young nodules are to be found in which there is no fungus, but these plants contain what is apparently the same fungus in all the older and most of the young nodules. The presence of the fungus is accompanied except in the youngest nodules with a rich development of proteids. The fungus-free nodules contain no stored-up

[1] Nobbe and Hiltner, Landw. Vers. Stat., 51 (1899), p. 241.

starchy or nitrogenous food material. The material in these richly stored older nodules can well be absorbed by the tree to judge from the number of flaccid or empty nodules with still sound exteriors and the partly decomposed conditions sometimes to be observed in the older nodules when examined microscopically. Tests for proteolytic enzyms in the nodules have not yet been made. Since nodules are formed without the fungus, the real problem in growing in nitrogen-free cultures is to test the comparative ability of plants with fungus-bearing nodules and those with nodules lacking the fungus to thrive under such conditions.

The royal palm and some other palms have "air roots" which are developed in abundance from roots which would otherwise have no connection with the air owing to being covered by thick, close, or water-saturated soils. Such roots are characterized at first by a somewhat swollen appearance not unlike that of the nodules. Later the epidermis breaks away and the underlying cells expand into a white spongy mass. This same spongy tissue is developed in older fungus-free nodules. The chief difference between the nodules and the root structures which clearly serve no other purpose than to aid the "breathing" of the roots is in size, the nodules being but 2 to 4 millimeters long, the corresponding part of the air roots reaching a size of 1 to 2 centimeters. The nodules are usually formed in loose soils or on roots growing along the surface of the soil beneath decaying vegetation. It would seem that the nodules are possibly air roots which possess the additional function of assisting the palm to secure a larger supply of nitrogenous food material.

REPORT OF THE ANIMAL HUSBANDMAN.

By E. G. Ritzman.

The work in anima. husbandry has been materially broadened during the past fiscal year. One of the chief lines now in progress is experimentation in animal breeding and acclimatization. Owing to lack of pasture lands and also to the unfavorable location of the station for stock breeding, a part of this work is being done in cooperation with breeders situated in more suitable localities. Some stimulus has been given to the stock industry by the insular fair held at San Juan during the month of February. This fair is of special interest in relation to the station work, as it is an agency to help promote interest in live-stock improvement. Nearly all the live-stock exhibits at the fair were importations from the States, but it is expected that the next fair will be more largely composed of native-grown or at least locally owned stock. Considerable interest was manifested in the splendid exhibit of chickens brought to the fair from the States which, when sold at public auction, brought exceptionally high prices. Horses also commanded considerable attention, and the prices obtained for them show that good light-harness horses are in demand. Cattle of beef type, including Herefords and Shorthorns, brought low prices at public auction. These sales reflect in a large measure the general attitude existing here toward foreign stock.

The station had a very creditable exhibit which attracted considerable attention and received favorable comment. It consisted of four bulls—Jersey, Guernsey, Shorthorn, and crossbred Zebu; Berkshire pigs; and poultry, including barred Plymouth Rock and White Leghorn chickens, White Pekin and Indian Runner ducks, Bronze turkeys, Toulouse geese, and Homer pigeons.

HORSES.

During the first part of the year the horses purchased in the States the year preceding were sent to various parts of the island, the older ones for stud purposes and the younger ones to localities more favorable for growing stock. They are all doing well and keep in good condition. One colt which had developed an acute case of osteoporosis here in Mayaguez was almost entirely cured after six months on the south side of the island.

Of the first lot of colts sired by the oldest horse 26 have already been foaled. These colts are much larger than pure native stock.

Some are from mares which are crossbred from native mares and American saddle-bred stallions. They are, therefore, three-quarters American saddle bred and should make a valuable improvement both in size, conformation, and color, but are as yet too young to give any definite indication of future development. A few mares have also been bred to the thoroughbred stallions during the year. These thoroughbred stallions are undoubtedly more closely related to native stock, but are much larger than the latter. They should, therefore, nick well, add considerable size, and preserve in the progeny the stamina and vigor which are notable characteristics of the breed.

CATTLE.

Cattle for strictly beef purposes are little in demand, and it is doubtful if such will attain popularity until the ox is replaced for working purposes. The available pasture lands are now hardly sufficient for the production of draft oxen and dairy stock, both of which are at present greater economic factors than beef cattle, inasmuch as these two classes of stock supply the demand for beef when they have become useless for work or milk production.

Methods of cultivation, class of labor, and the unsuitability of the larger draft horses to this climate, make the work ox necessary, at least for the present. The work begun last year in cooperation with cattle breeders on the south side of the island to produce a work ox which is larger, more active, and more resistant to ticks is now beginning to give results. Nearly 70 calves have already been sired by these crossbred Zebu with Shorthorn and Zebu with Hereford bulls. These bulls are now 3 years old, large, strong, very active, and possess superior qualities for beef as well as for work. Their tick-resisting qualities have been demonstrated, and their condition during the last drought was in favorable contrast to that of the cattle grazing in the same field. The calves sired by them are considerably larger than native calves and promise to develop more size. There is a strong demand from breeders of work oxen for the service of these animals.

There is always a great need for dairy cows that yield a fair quantity of milk. It appears to be the general experience that dairy cows brought from the States will not yield as large a quantity of milk in Porto Rico. This fact, together with some danger in their introduction, makes dairymen somewhat reluctant to introduce pure dairy cows which would otherwise find ready sale. In continuation of the work to improve dairy stock the station keeps three pure-bred bulls, Guernsey, Jersey, and Shorthorn. The service of these animals is much in demand and will no doubt add materially to the improvement of this class of stock. The two former were brought from the States during this year, and the latter was calved here from pure-bred

parentage. The station also has four crossbred Shorthorn native females bred at the station (Pl. IV, fig. 1) and one crossbred Hereford native cow. Although they are very pretty individuals, yet it is doubtful if crosses from beef breeds and native stock have any great economic advantage over selected native stock, as they are inferior for work and, with the possible exception of the Shorthorn cross, they are no improvement for dairy purposes. One breeder who has tried Herefords in the better grazing section states that they are absolutely unsuited to that section.

SHEEP.

There has been a limited demand for the African woolless sheep introduced during the previous year. Although they keep in fair health in this locality, yet they fail to put on flesh. On the other hand, sheep of this breed sent to the south side of the island, which is drier and more suitable for sheep raising, have done well. They keep in excellent condition on inferior pasturage and show considerable mutton tendencies. In addition to this they mature early, possess extraordinary fecundity, and have two lambing seasons a year.

The Southdown ram introduced during the year has been mated with native and African woolless sheep. Lambs dropped by the latter show dominance of the African sheep in color transmission and of the Southdown in wool development. Nothing can as yet be said regarding any improvement of mutton qualities. Even under the unfavorable conditions existing in this locality for sheep breeding this Southdown ram has kept in good health since his arrival, and that such sheep can be safely introduced into the drier sections of the island is beyond question.

PIGS.

A considerable number of Berkshire pigs, bred at the station, have been sold during the year as foundation stock to breeders. The demand for such stock is steady, and favorable reports have been received from many who have tried them.

A number of Poland-China, Duroc-Jersey, Hampshire, and Tamworth pigs brought from the States for exhibition at the insular fair were sold here for breeding purposes. Very favorable reports have so far been received of the Hampshires and Tamworths.

An interest in pure-bred pigs is gradually developing. Their rapid growth has made them a profitable side issue in the neighborhood of towns where kitchen offal can be obtained at a very low cost from hotels. Although the cost of corn and other pig feeds, such as ship stuff and slaughterhouse by-products, would make pig raising prohibitive if depended on solely, yet there is considerable profit in the utilization of kitchen waste where it can be obtained steadily, sup-

plemented by forage crops, palm seeds, etc., and to a limited extent by mill and slaughterhouse waste.

POULTRY.

The poultry stock has received an addition of Indian Runner ducks during the year. The interest in various breeds of poultry, especially chickens, is steadily increasing, as is shown by the sale of birds and eggs for breeding purposes. The year's sales included 50 chickens, 24 ducks, 4 geese, 12 Homer pigeons, and 150 settings (1 dozen each) of eggs. The effect of such sales is already very noticeable throughout the island. Pure-bred birds or crosses from Plymouth Rocks can now be seen in almost every locality. The correspondence concerning requests for information on care and treatment of poultry is also growing.

DAIRYING.

A dairy has been begun, and the milk is handled under as sanitary conditions as the limited laboratory appliances now available will permit. The chief object so far has been to demonstrate methods of handling milk in a more sanitary manner than is now generally done. There has been great demand for the milk so handled. Some butter was also manufactured, and it was found that butter can be made which is of good quality when milk can be properly handled in cold storage.

Dairy conditions on the island have received a decided impetus by the organization of a dairy company in Ponce. This company has erected a large modern factory, with equipment of the most improved type, and milk is handled under sanitary conditions from the time it is milked until it reaches the consumers. A good quality of butter is also manufactured by them, and depots are located in the principal cities of the island where these products are retailed at a moderate price.

STOCK FEEDS AND FORAGE CROPS.

Stock feeds and forage crops still maintain a standard of prices which acts as a great drawback to a greater development of the live-stock industry. The number of stock kept on the island is about the maximum which present conditions of feeding and feed production will maintain. That a much greater number of stock could be maintained and brought through the whole year in better shape by the adoption of a system of forage production is beyond doubt.

The work of making and feeding silage at the station has been continued. The result of three years' investigation indicates that the production of good silage offers fewer obstacles than in colder climates, and, further, that native stock as well as imported stock will eat it readily. At the station corn, whole cane, cane tops, and malojilla or Para grass have all given satisfactory results for silage. Para grass

is difficult to bring through in good condition, as it is very light and does not settle or pack sufficiently unless heavily ballasted. After two failures to make good silage from Para grass another attempt was made in which the grass was covered by about 6 feet of cut corn for ballast. This kept in perfect condition, and there was only a very small percentage of loss. Corn silage is most readily eaten, but the results of feeding experiments show that when properly made and fed cattle will eat cane tops also. This would mean a great saving of feed, a large part of which is generally regarded as waste, and would help cane planters to bring their working oxen through in better shape and on less acreage.

Some preliminary investigations in the production of forage crops which are especially suited to dry seasons and hill regions have been begun (Pl. IV, fig. 2). A few grasses and a number of sorghums have been planted so far. One of these sorghums, introduced from Barbados, promises to be an especially valuable crop. Small plats grown during the dry season gave a yield of 20 tons of forage per acre with a heavy yield of seed, and when grown during the wet season it gave 50 tons of forage but did not develop seed. If cut constantly before it blossoms it is perennial in habit. Sword beans and cowpeas also grow luxuriantly with sufficient moisture. Rape thrives well in suitable soil and makes a valuable feed, as it requires little cultivation. Of the grasses tried during the last year *Paspalum dilatatum* appears to be a valuable addition to withstand long droughts, but it requires a well-cleaned soil for a start, else native grasses and weeds will choke it out. Rhodes grass is also being grown, but has not yet been tried on a large area and left to contend with other grasses.

MINERAL NUTRITION.

The investigations begun last year in mineral nutrition with pigs have been concluded and the results compiled for publication. These results indicate that calcium chlorid can be used profitably as a supplement to bone meal in rations deficient in calcium. The results further point to the fact that mill feeds, such as middlings and shorts, which are notably poor in calcium, are, on the other hand, too high in magnesium unless supplemented by a sufficient amount of calcium. A study of the relationship between calcium and magnesium and their effect on digestion and assimilation shows that an excess of magnesium retards assimilation and increases the cost of growth unless there is present a sufficient amount of calcium to neutralize the effect of the magnesium surplus. Comparisons of calcium chlorid with tricalcium phosphate (bone meal) show that there is only a small variation among individual pigs in utilization of calcium chlorid, whereas there is a wide difference among individual pigs as regards utilization of bone meal.